2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Wireless airflow monitoring system for respiratory gating

Suja Mary Joseph*, *Student Member, IEEE,* Boris R. Bracio, *Member, IEEE*

***Abstract*— The paper introduces an embedded flow rate measurement system with a user interface to visualize data. The sensor transfers flow data to the microcontroller through I2C protocol. The microcontroller then wirelessly transmits data to a laptop by Bluetooth low energy. Qt creator is used to develop a user interface to visualize the flow rate waveform and Bluetooth profile of the device.**

***Clinical Relevance*— Respiration induced motion introduces uncertainties in radiotherapy treatment of the lung. The treatment field is often wide to compensate and invariably leads to irradiation of healthy tissues. Respiratory gating is one of the solutions [1] and this requires a real-time respiratory monitoring system. It should also be minimal in order to not physically interfere with the treatment setup or cause anxiety to the patient.**

I. INTRODUCTION

Airflow measurement is one of the common methods used to find respiratory parameters [2]. The project utilizes a digital flow sensor that has an I2C interface. I2C (Inter-Integrated Circuit) is a communication protocol for short distances that connects the master (microcontroller) and slave (sensor) via two wires. Additional circuitry has been eliminated by selecting a digital sensor, making the design minimal. Bluetooth Low Energy (BLE) is a wireless communication technology with reduced power consumption. The microcontroller and the laptop communicate via BLE.

The project has been designed keeping in mind the design requirements of non-invasiveness, low power consumption and minimal hardware. A small PCB (printed circuit board) can be designed to accommodate the sensor and microcontroller which can then be attached to a medical mask. This makes it convenient to use the system alongside other treatment or diagnosis setups and causes less anxiety to patients.

II. SYSTEM DESIGN

A prototype of the system was designed and developed (Fig. 1). An Ambu bag is used to simulate respiration due to hygiene concerns amid the pandemic. The SFM3000 flow sensor from Sensirion is connected to the development board from Texas instruments for the CC2652R microcontroller. A Veroboard circuit of pull up resistors for the I2C wires interfaces the sensor and microcontroller.

The microcontroller program is written in C language to process the sensor data, build a Bluetooth profile for flow rate and transmit data via BLE. The microcontroller-sensor forms the server (transmitter), and the laptop is the client (receiver) for wireless communication. A client application was developed with Qt creator, which is a C++ application development framework. The user can use the desktop application to connect to a BLE device, display Bluetooth services of the device, continuously read flow rate from the server and plot the flow rate waveform in real-time.

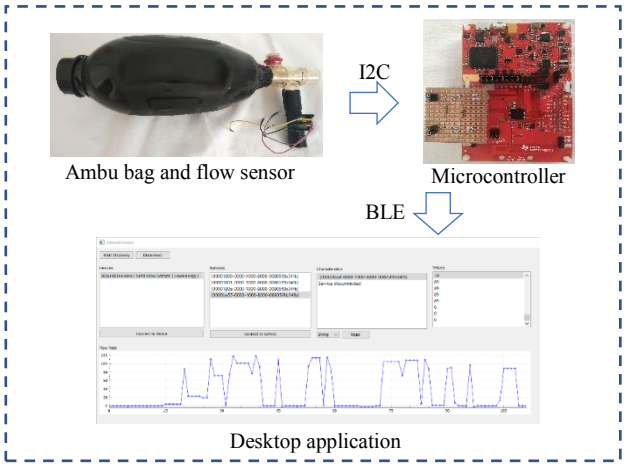

Figure 1. Wireless respiratory monitoring system

III. FUTURE WORKS

The project can be implemented along with a virtual reality lung model for respiratory gating. The flow rate can be used to calculate respiratory movement, which could be utilized to make the lung model dynamic. This system would provide real-time visualization of the lung and tumor movement to adapt radiotherapy.

ACKNOWLEDGMENT

This project was carried out as a part of Directed Research Studies in the Department of Biomedical Engineering, Anhalt University of Applied Sciences, Köthen. I would like to thank Prof. Boris R. Bracio and my colleagues for their support.

REFERENCES

[1] Yoganathan, S A et al. "Magnitude, Impact, and Management of Respiration-induced Target Motion in Radiotherapy Treatment: A Comprehensive Review." Journal of medical physics vol. 42,3 (2017): 101-115. doi: 10.4103/jmp.JMP_22_17

[2] Massaroni, Carlo et al. "Contact-Based Methods for Measuring Respiratory Rate." Sensors (Basel, Switzerland) vol. 19,4 908. 21 Feb. 2019, doi:10.3390/s19040908

*Research supported by Anhalt University of Applied Sciences.

Suja Mary Joseph is with Anhalt University of Applied Sciences, Köthen, 06366 Germany, phone: +49 1520 5484144; e-mail: suja.m.joseph@student.hs-anhalt.de).